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SE..ION AND TESTING OF PAYLOAD MONITORS FOR HYDRAULIC LOADING EQUIPMENT

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SELECTION AND TESTING OF PAYLOAD MONITORS FOR HYDRAULIC LOADING EQUIPMENT

by

V.Srajer*.

ABSTRACT

Two payload monitoring systems were recently investigated by Westar's mine engineering staff for application at Greenhills mine in Elkford, B.C. The systems are WT-4000 developed by Wrey Technologies, Sydney, NSW, Australia, and Loadrite, developed by Teledyne Canada, Thornbury, Ontario.

The Surface Mining Laboratories co-operated with the mine staff during selection and testing of one of the system, WT-4000, installed on a Demag H-241 hydraulic shovel at the mine. The system was operational for approximately two months during early 1989.

In this report both monitoring systems are described, followed by presentation of WT-4000 system advantages and disadvantages during the testing at the mine.

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SÉLECTION ET ESSAI DE MONITEURS DE CHARGE UTILE POUR LE MATÉRIEL DE CHARGEMENT HYDRAULIQUE

par

V. Srajer*

RÉSUMÉ

Deux systèmes de monitorage de la charge utile ont été récemment étudiés par les ingénieurs de la mine de la Westar en vue d'une utilisation dans la mine de Greenhills à Elkford (C.-B.). Il s'agit du WT-4000 mis au point par la société Wrey Technologies de Sydney (NSW), Australie, et du Loadrite, mis au point par la société Teledyne Canada de Thornbury (Ontario).

Les Laboratoires de l'exploitation à ciel ouvert ont coopéré avec le personnel de la mine pour le choix et l'essai de l'un des systèmes, le WT-4000, installé sur une pelle hydraulique Demag H-241 dans la mine. Le système a fonctionné pendant environ deux mois au début de l'année 1989.

Dans le présent rapport, les deux systèmes sont décrits puis les avantages et les inconvénients du WT-4000, observés lors des essais à la mine, sont présentés.

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INTRODUCTION

Mine operators are investigating means to monitor payload weight on trucks to establish some reasonable estimation of carried load for production reporting. Some mining companies prefer to use weighing systems on trucks, some are looking for monitoring devices to be installed on the shovels or loaders.

At the present time, the search for reasonably accurate, reliable and time efficient monitoring systems continues. Several monitoring devices were tested in the past, such as OBDAS at Gregg River mine (1) to monitor truck load, and SPARC, BEPAL II, GE SPM-8000, IS-173, and others to monitor shovels or loaders (2, 3).

Two new monitoring devices were investigated for the Greenhills mine in Elkford, B.C.: WT-4000 and Loadrite. Both systems were developed for installation on hydraulic loaders. The WT-4000 system was previously tested on Komatsu's wheel loaders operating in NSW in Australia, Loadrite was installed on several Marathon LeTourneau front-end loaders in Ontario and on Broyt hydraulic excavators in Norway. Both suppliers claim satisfactory performance of their system.

The purpose of the test installation at Greenhills mine was to evaluate usefulness, accuracy and reliability of the systems under various operating conditions on a hydraulic shovel.

LOADRITE SYSTEM

PRINCIPLE OF OPERATION

The Loadrite weight indicator has been designed for use on front-end loaders and other machines using hydraulic lifting cylinders. The payload in the bucket of the loader can be weighed by measuring the hydraulic pressure at the lifting cylinder that is required to raise the load. This pressure is

converted by the pressure transducer into a signal processed by a microcomputer to display the actual weight of the load. The empty bucket is zeroed out so the 'Load' diplays only the payload.

During the weighing of the payload, the loader must be stopped on level ground and the load must be raised at pre-determined RPM. A tachometer is installed on the machine to facilitate duplication of the weighing procedure. When the bucket is raised to the appropriate level, a trigger device is activated and the weight is displayed on the console. The weight is held on display for up to 8 seconds during which time the operator may add it to the total weight accumulator.

Once installed and calibrated, the system is accurate within 1 percent. The display is mounted in the operator's cab (Fig.1) and is quite easy to learn and operate. There are three modes of operation: firstly, the operator may choose to weight each load separately, secondly, totals may be monitored for full truck load or shift operation, and thirdly, the operator may set 'target weight' so each bucket load is substracted from the target weight until it is reached. A remote 'ADD' button can be installed on a lever control, the floor or any other convenient location for ease of use. This will allow operator to quickly add the bucket load to the 'Total' displayed, as well as add the load in the unit's memory. The system operates on either a 12 or 24 Volt system. An optional printer or audible overload alarm can be installed with the system.

GENERAL DESCRIPTION

The Loadrite has three main functions:

1. Measure the weight of the payload,
2. Accumulate the weight of a pre-set series of payloads to monitor over- or under-loading, and
3. Accumulate the total weight of product loaded over a period of time for shift, day, week, etc. reporting or for inventory control.

The system has two digital displays which have the following functions:

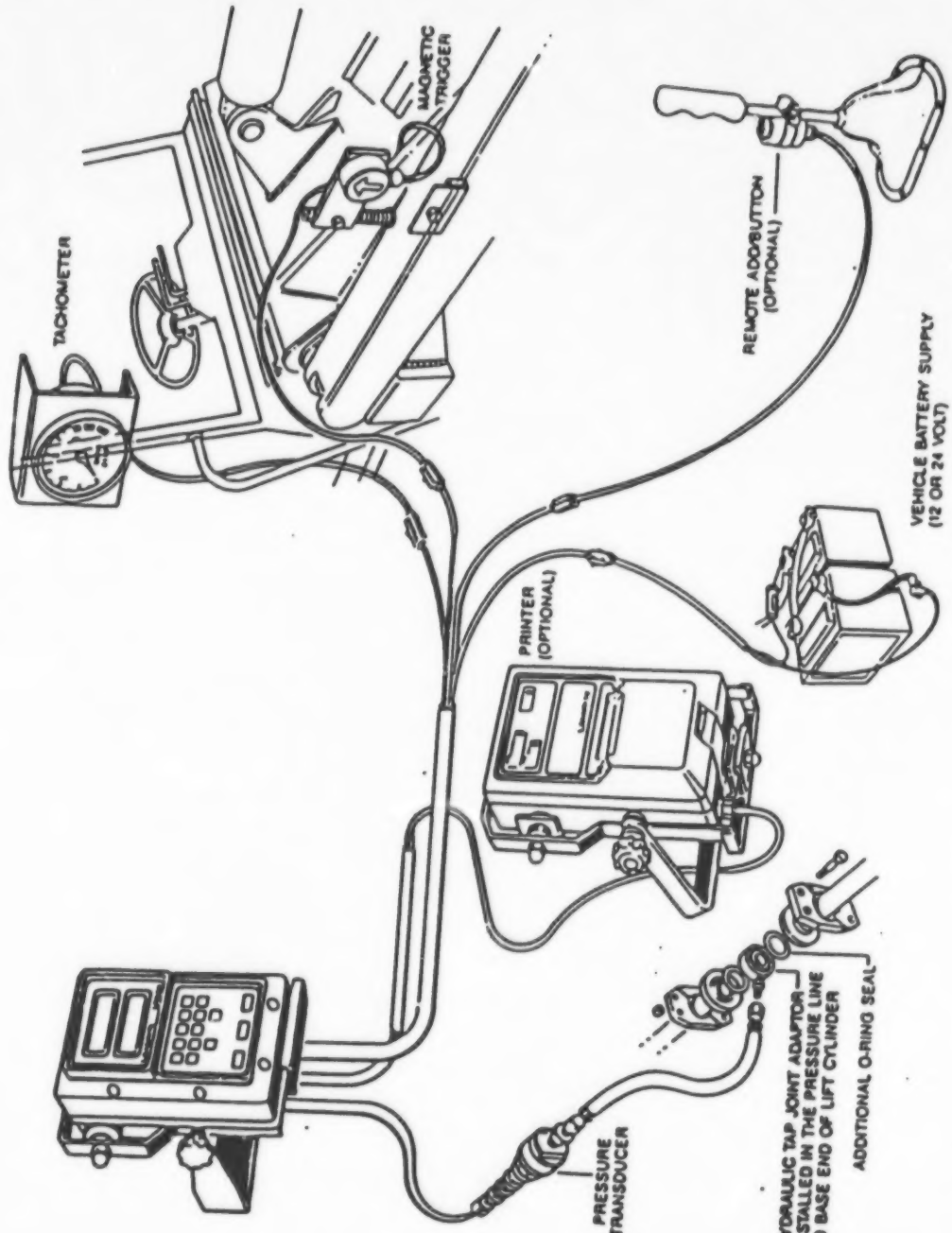

TACHOMETER
MAGNETIC TRIGGER
REMOTE ADD/BUTTON (OPTIONAL)
VEHICLE BATTERY SUPPLY (12 OR 24 VOLT)
PRINTER (OPTIONAL)
PRESSURE TRANSDUCER
HYDRAULIC TAP JOINT ADAPTOR INSTALLED IN THE PRESSURE LINE TO BASE END OF LIFT CYLINDER
ADDITIONAL O-RING SEAL

Figure 1. LOADRITE Schematics

1. LOAD

Indicates weight of product in the bucket.

2. TOTAL

Shows the total accumulation of weights added to the memory previously. This accumulation may be for short or long period of time. In essence, two displays may be provided, one called 'SHORT ACCUMULATOR' for data stored for truck load, or 'LONG ACCUMULATOR' for data stored over shift, day, etc. The first display is always cleared to zero after reset.

The displays are also used to show time of the day, date and number of loads to be added to accumulator.

The monitor has a waterproof membrane keyboard with 15 keys for control of the system functions. No internal adjustments are needed during calibration of the monitor. The control unit has three connectors with the following functions:

- connection to the pressure transducer,
- connection to an optional printer, and
- connection to auxiliary functions, such as power supply to the battery, to the trigger device (magnetic switch), external overload audible alarm, and remote 'ADD' button.

The system is housed in an anti-vibration rubber frame with a universal mounting bracket for mounting in a convenient position in the loader cab.

SPECIFICATIONS

The specifications of the Loadrite monitoring system are shown in Table 1.

Table 1. LOADRITE Specification

GENERAL

Dimension	11 X 7.1/2 X 3.1/2
Case Material	Macroblend (polycarb/polyester alloy)
Frame and Mounting Material	Zinc plated steel Epoxy powder coated
Ambient Temperature	Operating - 14°F to 122°F (-10°C to 50°C)
	Storage - -5°F to 175°F (-20°C to 80°C)
Humidity	0 - 95% R.H.
Connectors	Waterproof Amphenol
Weight	With Mounting Bracket 5lbs.
Tachometer	Electronic
Type	Alternator
Range	0 - 4000 rpm.
Size	3.3/8 Face diameter
Ambient Temperature	-40° to 180°F (-40°C to 85°C)

ANALOG INPUT AND A/D CONVERSION

Full Scale Input Range	0.8mV - 23mV
Input Sensitivity	0.2uV/incr - 115uV/incr
Input Signal Range	-1 to 23mV
Zero Adjustment Range	-1 to 8.5mV
Pressure Transducer Excitation	10Vdc ±1%, 80mA max
Long Term Stability	0.08% F.S. per year typical
Temperature Co-efficient	Span 0.01% FS/°C Zero 0.015° FS/°C
Non-linearity	0.01% F.S.
Input Noise	2uV p-p
Input Impedance	1 Mohm minimum
Input Overload Tolerance	±50V minimum
A/D Conversion Method	4 phase integrating dual slope
A/D Resolution	128000 counts
A/D Conversion Time	200ms
Input Common Mode Rejection	80db
Input Normal Mode Rejection	120db @ 50Hz
Analog Filter	4Hz, 2 pole low pass

PRESSURE TRANSDUCER

Pressure Range	5000 psi (350 BAR) @ 3mV/V sensitivity 1000 ohm bridge
Accuracy	0.25% F.S. combined non-linearity, hysteresis and repeatability
Maximum Over-range Pressure	2 X F.S. pressure
Maximum Safe Pressure	4 X F.S. pressure
Temperature Co-efficient	Zero: 0.02% F.S./C Span: 0.02° F.S./C
Operating Temperature Range	14°F to 212°F (-10°C to 100°C)

POWER REQUIREMENTS

Voltage	12 - 24 volts
Power Consumption	60 mA maximum
Lower Power Supply	Automatically shuts down system to protect memories if supply voltage drops below 11 volts D.C.
Stand by Battery	9 volt alkaline
Stand by Current	30uA maximum, 15uA typical
Battery Life	12 months minimum 24 months typical

DIGITAL SECTION

Microprocessor	8 bit, single chip MPU
Weight Display	5 digit 0.5" LCD
Accumulator Display	6 digit 0.5" LCD
Backlighting	Incandescent long life lamps
Decimal Points	Selectable: 0,1,2 or 3
Scale Increments (graduation)	1,2,5,10,20,50,100,200
Max Display	95000
Push Button Zero Range	Approx. -10% to 100% F.S.
Overload Alarm Range	Selectable 0 - 100% F.S.
Clock Calendar	24 hour format Date - day/month/year Battery back-up

OPTIONAL EQUIPMENT

(a) PRINTER OUTPUT Protocol	RS232C, ASCII, approx. ±9 volts into 4 kohms
Printer power	Unregulated voltage from vehicle battery supply included in printer cable loom from LR500 control unit.
(b) EDP DATA OUTPUT Protocol	RS232C, ASCII approx. ±9 volts into 4 kohms.

WT-4000 SYSTEM

PRINCIPLE OF OPERATION

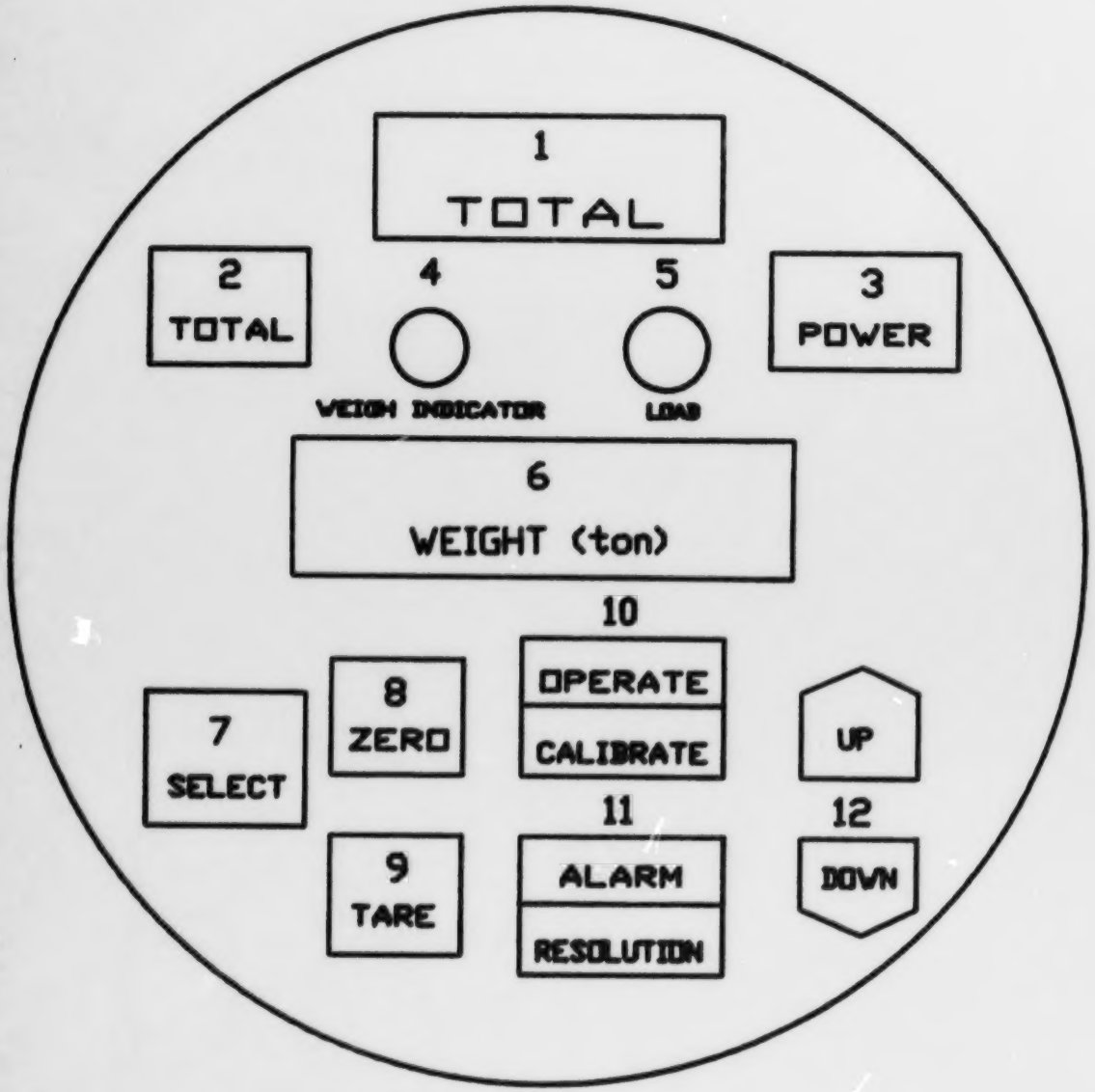
The WT-4000 load monitoring device was designed by Wrey Technologies, Inc. of Sydney, NSW, Astralia, and is marketed in Canada by KES Resources Ent. Ltd., of Calgary, Alberta.

The system is firstly calibrated for the machine during its installation. When the system is activated, several seconds pass before it is ready for monitoring. During this time, self check of the internal computer is completed. In the operating mode, the lower display indicate a weight in the bucket, while the upper displays total weight for a pre-determined period of time. The weight displayed is valid only for set up conditions used during the calibration. Other times it is indicative of the pressure fluctuations in the hydraulic system. As the load is raised, the sensed pressure consists of contributions from fluid movement, friction, weight of machine components and the weight of the load. Provided that the components other than the load are constant and the same as existed during calibration, the pressure measured by the transducer represents the weight of the load being lifted. In order to achieve this, speed and the tilt of the machine must be controlled.

The load is measured as the bucket is raised through a defined position set by a proximity switch, where the machine-generated pressure contributions are known. When the weight sensing is completed, the display of the load weight is shown for 25 seconds, then the weight is added to the 'TOTAL' weight, displayed on the upper window. An alternative mode of display may be programmed if desired by the operator.

GENERAL DESCRIPTION

A schematic of the WT-4000 is shown on Fig. 2. The display indicates power on/off, weight and total accumulated weight, weight position indicator, and a set of keys used for calibration, zero set-up, and trouble shutting. The keys have the following function:



1 TOTAL WINDOW
2 TOTAL KEY
3 POWER ON/OFF
4 WEIGHT INDICATOR
5 LOAD INDICATOR
6 WEIGHT DISPLAY
7 SELECT KEY
8 ZERO KEY
9 TARE KEY
10 OPERATE KEY
11 ALARM KEY
12 UP/DOWN KEY

Fig. 2 WT-4000 Schematics

POWER ON/OFF

Turn power to instrument.

WEIGHT DISPLAY

Display lifted weight in tonnes (or other units).

TOTAL DISPLAY

Displays total and when keyed also alarm level.

TOTAL KEY

Used for manual entry only.

AUTO TOTAL

Lights up when unit is in 'AUTO TOTAL' mode.

LOAD INDICATOR

Lights when signal output is steady.

SELECT KEY

To be used in conjunction with other function keys, such as ZERO, UP, DOWN, etc.

ALARM RESOLUTION KEY

When used with SELECT the resolution and alarm mode is set. It may also be used to switch between resolution and alarm setting.

ALARM KEY

When pressed alarm level will be displayed.

ZERO KEY

To be used when total display is to read zero or to cancel tare weight on tare mode or during calibration.

TARE KEY

Pressing this key with load in bucket and in weigh position will enter the tare weight. It can also be used in conjunction with SELECT KEY when a tare weight is entered manually.

OPERATE KEY

Pressing this key returns the instrument to operating mode when is in tare or resolution modes, indicator will light up and still light up when in normal operation.

RESOLUTION KEY

Used in conjunction with SELECT KEY to key in weight resolution.

UP/DOWN KEYS

To be pressed when keying in the calibration weight, alarm levels and setting resolution.

Once a weight has been recorded, it may be added to the accumulated total in the upper window, when TOTAL is pressed. If this is not done within the 25 seconds hold period, the result will be lost and will not be available for adding. Once the load has been added to the total, it cannot be added again by lowering and raising the bucket through the weighing position. The system must sense firstly a load approaching zero before it will re-adjust for new load. This will give the operator freedom to move the load back and forth through the weighing position during transportation, for as long as the bucket is not lowered to the ground.

The system can also work in test program. A set of up to seven check point displays are produced. After completion of the test, a '0' appears in the lower display to start an other operation. During the testing procedure, care is taken to preserve the calibration of the monitor in the memory.

Provision has been made for connection of a printer via a serial port optionally added to the WT-4000. Date and time are also entered to the system, using the resolution setting mode.

TESTING AT GREENHILLS MINE

The WT-4000 system was selected over Loadrite system to be tested at the Greenhills mine for the following reasons:

- cost of the instrumentation was lower,
- installation was on a trial basis, no up-front purchase was necessary,
- company promised service/replacement during the test,
- supplier was located closer to the mine,
- operation of the system is simpler,
- machine does not need to be absolutely level for weight reading,
- easy selection of alternative modes,
- large weight display,
- holding of display during loader's movement, and
- automatic or manual entry of data.

The system was installed on a Demag H-241 shovel (Fig. 3). The display located in the operators cabin is shown on Fig. 4. The testing

Figure 3. Demag H-241 Shovel

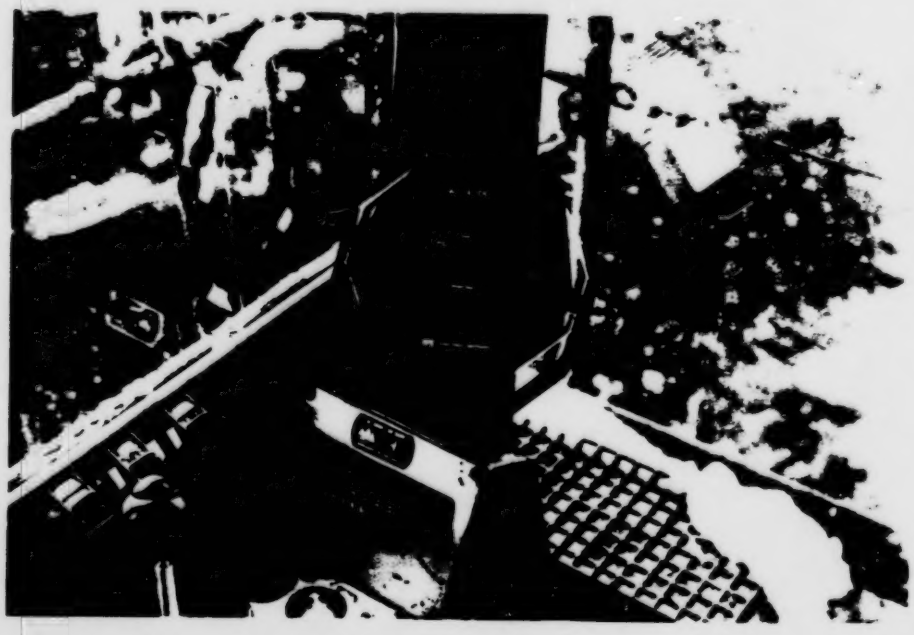


Figure 4. WT-4000 Display in Operators Cabin

commenced in February 1989 and was originally scheduled for one month only. After one month an extention was negotiated with the supplier for another month, because the mine was not fully convinced that the data collected were reliable. After two months of testing the following was concluded:

1. The weight data provided by the system are accurate to +/- 2 percent, when measured with alternate weighing system (scale),
2. The system is easy to learn,
3. The system set up is logical, operator's manual is understandable,
4. The display in the cabin and outside sensors are of solid construction and dependable. The instruments operated in minus 35 degree cold with no problem at all,
5. The instruments are well sealed, no dust inside was apparent,
6. There is considerable delay in cycle time in order to raise the bucket over the defined sensing point. During this lifting of the bucket an operator can not turn or do any other maneuevering with the shovel. It was estimated that this constraint increases shovel cycle time up to 25 percent.
7. Remote control to transfer data to 'Total' should be installed in easy to reach location, and
8. Calibration of the instruments should be simplified.

The mine personnel decided to return the system to the supplier after the test was completed, because they do not feel it will work to their advantage, the delay caused by lifting of the bucket through sensing point is too long. In general, they believe, the system may work with any front end loader, because the loader is stationnery when bucket is raised and load dumped into the truck or bin.

ACKNOWLEDGEMENT

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